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Design and Development of Arduino Healthcare Tracker System for Alzheimer Patients

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Abstract—Nowadays after the revolution of robotics in industries, the healthcare and position monitoring systems became more and more demanding. The target position monitoring of an object will help for the better navigation as well as control of systems. One of the fields, which today use this kind of tracking, is the patient control like Alzheimer patients or handicap people. This paper is about an Adriano based positioning and healthcare system developed to help Alzheimer's patients and their caregivers to track patients and monitor their vital signs remotely. The result of the system and the case study obtained shows the capability of the system to handover this task and use as the helper for Alzheimer patients in various situations.

Keywords—Arduino; positioning systems; healthcare; Alzheimer's patients

I. INTRODUCTION

Alzheimer's disease is a type of dementia that causes a problem for memory, thinking and behavior. It starts slowly and become worse and over the time become strong enough to affect daily activities.[1] In 2010, more than 35 million people were experienced Alzheimer's disease all around the world which 54 percent of them live in countries with low or middle incomes [2-4], Global cost of illness for Alzheimer's disease increased from US$315 billion in 2005 to US$422 billion in 2009. [5-6] One of the biggest problems with Alzheimer's patients is that they can easily get lost [1], especially when they are out of home and alone. Therefore, having a proper tracking system is vital. The prior studies [7] shows positioning systems are divided into indoor and outdoor. The indoor positioning systems are separated into infrared, ultrasonic and RSSI (Received Signal Strength Indicator) methods; and outdoor methods consist of GPS, GSM and Wi-Fi hotspots RSS.Figure 1 shows a summary about indoor and outdoor positioning systems. [7]

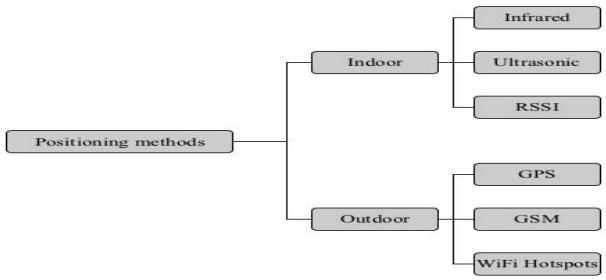

Figure 1 Positioning Methods

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For outdoor positioning, GPS method could be asuitable option because of the price and accuracy. In the developed system a GPS module is used to determine the location of the patient due to the reasons mentioned above. [8] As already mentioned, one of the biggest problems that Alzheimer's patients face is getting lost when they are out of home. Therefore developing a cost efficient system that can determine geographical coordinates of the patients is necessary. In this design, the Arduino is used as the main controller. The previous researches showthe usage of Arduino on Fuzzy knowledge based controller [9], Controlling CNC systems [10], Wireless Intrusion Detection [11], Measure and Control physical parameters [12] and etc. The novelty of current paper is using the Arduino for the Alzheimer's people.

II. SYSTEMS DESCRIPTION

Developed system is able to track the patient location and also determine the vital factors of the patient, such as temperature and heart beat. The system is also able to save these data to a micro SD card and send the information's received to care givers every 5 minutes. To determine the vital signs of the patient, a temperature and a heart beat sensor is used which send data to the microcontroller for processing. The next section describes the general overview of hardware design, algorithm and flowchart is given, and finally this paper concludes with the result section, which represents usage of this system in a two-month period.

III. HARDWARE

The proposed system consists of an Arduino Mega microcontroller as the main processing unit of the developed system, which receives data from heart beat and temperature sensors and processes these data to determine if the patient is experiencing any critical condition. In the next step the data collected from sensors along with date and time will be stored on SD card memory for further reference and in special cases like an emergency situation or an accident. Finally patient's coordinates and vital signs will be sent to the caregiver by a short message using a GSM module.

A. Arduino Mega

Adriano Mega is an open source microcontroller based on A Tmega 2560 chip with a 16 MHz crystal oscillator. It has 54 digital inputs/output pins which 15 of them can be used as PWM outputs. This microcontroller supports up to 16 analog inputs and 4 USARTs ports [13].This board can be powered using a USB cable or with an AC-DC adapter or battery which should provide at least 5v voltage and 500mA current to work properly.

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A brief specification for this board is given in table 1. [13]

TABLE 1 Arduino Mega features:

Microcontroller	ATmega2560
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	54 (of which 14 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB of which 8 KB used by boot loader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz

B. Sim 908

Sim908 is a communication module, which supports quad band networks and uses GPRS multi-slot class 10. This module also has a built-in GPS module, which can be used to find geographical coordinates.[14] One of the biggest advantages of this module is that it contains both GSM and GPS modules in one package and it has a reasonable price, which makes this project more cost effective. This module needs a 5v/1A DC power supply to work properly. Sim908 uses AT Commands to communicate with the microcontroller through the serial port. In this project the second serial port of the microcontroller is connected to the Sim908 serial port. [14]

C. LM 35

To determine the body temperature of the patient, popular LM35 sensor is used as a prototype. In this sensor, temperature has a linear relationship with output voltage of sensor. Every 100 mV output voltage represents one centigrade. Operational temperature of this module is between -55 and 150 centigrade degree. To obtain the best performance input voltage must be between 4 to 20 volts. [15] In this project LM35 is connected to ADC (analog to digital converter) port number 1 on Arduino Mega microcontroller.

D. SD card module(LC studio sd card breakout board)[7]

To save the collected data from sensors, a SD card module is used in this project. This module uses SPI (Serial Peripheral Interface) protocol to connect to microcontroller. To power on this module a 5 or 3.3 volt power supply is needed. Before starting this device, SD card should be formatted in FAT protocol using a computer. [16]

E. Heart beat sensor (SEN 11-574)

Heart beat sensor used in this project is developed by the pulse-sensor [17]corporation, which has a very small size and can be attached to patient's body. It has 16mm diameter and about 3mm thickness. In this sensor, after receiving light reflection from patient's capillaries, sensor sends a pulse to amplifier. Microcontroller reads this pulse every 2 millisecond (created by Arduino Mega Timer number 2) and after at least 10 pulses, microcontroller determines average value of this signal and uses this signalto determine patient's beat per minute.[17]

Table 2 shows brief overview of hardware used in the project and also reasons why these types of hardware are selected.

Table 2

	Hardware name	Features	Communication method
Micro Controller	Arduino Mega	Reasonable price, Rich platform, Open source libraries	--------
Temperature Sensor	LM35	Low price, Small size, Good accuracy	Directly by the analog pin
Positioning and Communication Sensor	Sim908	It contains both GSM and GPS modules in one package	Serial
Healthcare Sensor	Heart beat sensor	Small size, High accuracy,	Directly by the analog pin
Storage	SD card	Easy to use setup, Low price	SPI

In figure 2, the connection between Arduino and the other parts of the system is shown and in figure 3the hardware connection diagram is shown.

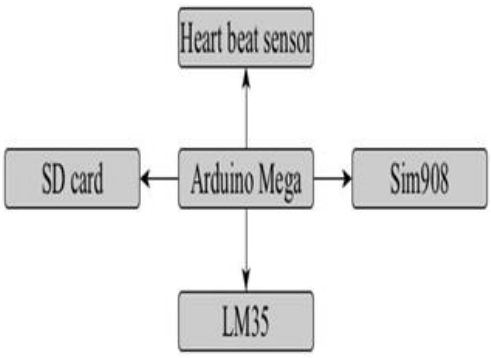

Fig 2 Connection between parts of developed system

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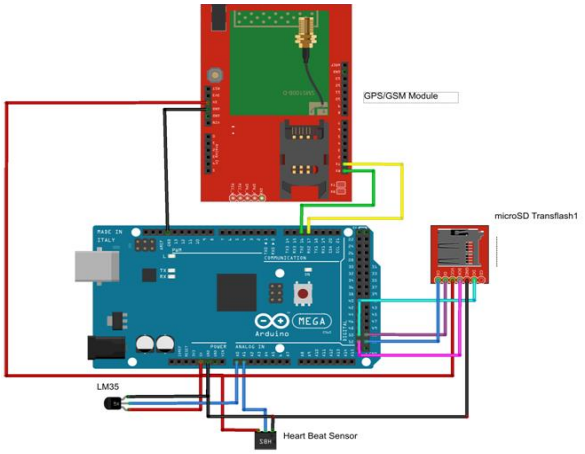

Fig 3 hardware connection diagram

IV. ALGORITHM AND FLOWCHART

The proposed system uses 15-minute timer to send collected information from sensors like temperature and heart beat alongside with geographical coordinates to patient's caregiver. Every time that timer triggers, developed system also store those information on SD card for further reference.

After collecting the data from sensors, these data alongside with date, time and geographical coordinate received from GPS module, are stored on SD card for emergency situations. The vital signs and geographical coordinate will be sent to the caregivers every 15 minutes to inform them about health status and location of the patient. If the system detects that the patient is experiencing a critical condition, it will send messages to caregivers every 5 minutes.

Reading temperature value from the LM35 takes care by Analog Read function, which is a built-in function in Arduino programming environment. This function reads the analog input from temperature sensor that is connected to ADC (Analog to Digital Converter) port number 0 on Arduino Mega microcontroller. After reading data from analog sensor, this value should be multiple by reference voltage which is 5 and then should be divided into ADC (Analog to Digital Converter) resolution which is 1024. The obtained value represents the received voltage from temperature sensor. According to LM35 data sheet, every 100 mV output voltages represents one centigrade that1000/10 to obtain actual temperature of patient should multiply means, obtained value.

When reading data from sensors is done, it is time to get geographical coordinates from GPS module and store all the data received from sensors alongside with date and time on SD card and afterward, send vital signs and coordinates to care-givers via SMS. As mentioned earlier, using AT Commands does communication with GPS/GSM module with microcontroller. Microcontroller sends commands and waits for module to answer. If module sends appropriate respond, microcontroller processes the incoming data and extracts useful information from the received string like latitude and longitude.

The developed system monitors vital signs of the patient simultaneously and if heart beat drops below 45 BPM (Beat Per Minute) or become greater than 200 BPM (Beat Per Minute) and/or temperature exceeds 36-38 ranges, system detects a critical situation and sends vital signs every 5 minute to caregivers. Figure 4 shows the developed system algorithm.

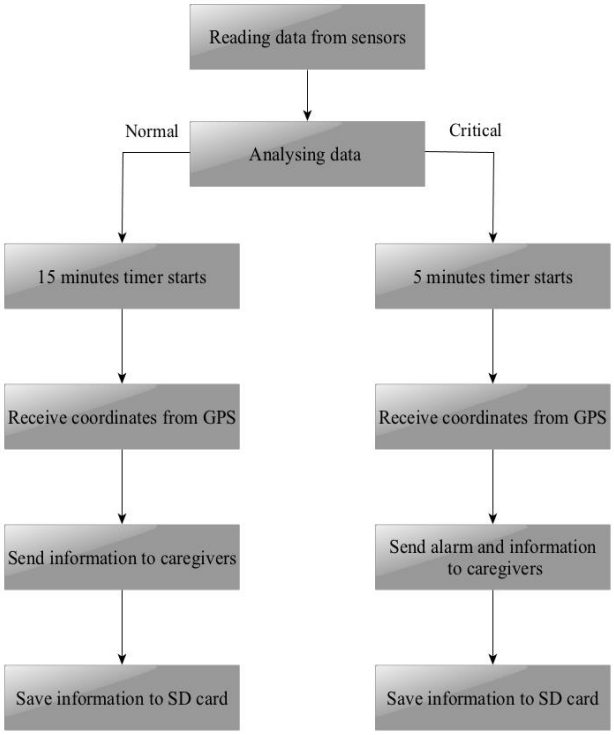

Fig 4 developed system algorithm

V. RESULTS

As the case study for the system, trail have been done over 60 sample persons and the system SMS the vital parameters such as temperature and beat rate as well as latitude and longitude to carrier. Also, the mentioned data will be logged into the SD card for further studies. The data can be loaded into Google maps to track and find the patient's location.

The prototype of developed system and hardware used in the system is shown in figure 5.

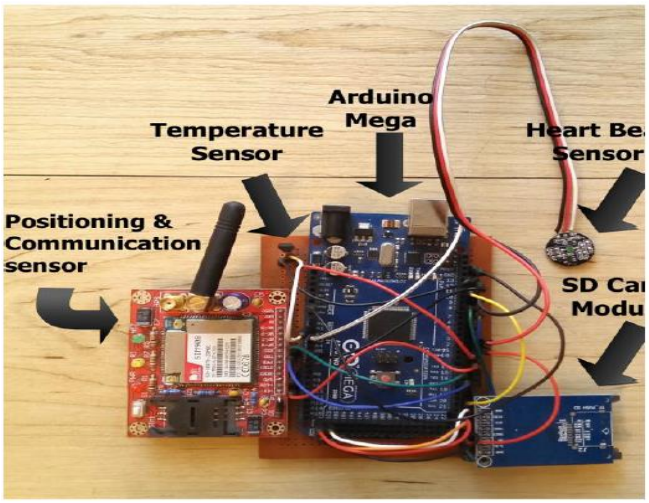

Fig 5 system prototype

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The main timer is set to 5-minute instead of 15 minutes to gather more information in less time. Figure 6 shows received messages in 5-minute interval including temperature, coordinate and beat per minute.

Fig 6 recived messages

As a sample, the figure 7 shows the patient's movement in the city. Developed system logs the coordinates every 5 minutes in 35-minute interval.

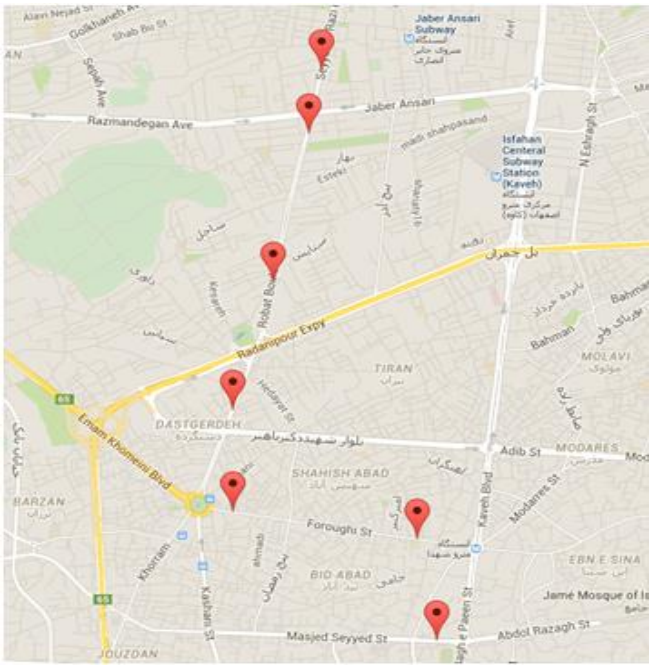

Fig 7 patient's coordinates on map

The developed system has some advantages comparing to similar systems mentioned below:

1. Having a highly accurate heart beat sensor.
2. Logging gathered information on SD card.
3. Detecting patient's critical situation and inform caregivers immediately.
4. Using the reasonably priced Arduino Mega, based on more features.

Considering the cost of SMS in different countries price of sending SMS is different. For making the system more cost efficient, the time interval can be changed to meet the carrier's requirements.

After doing some tests, developed system experienced two major problems. First problem is that the GPS module is not responsible in indoor environments. The reason for this problem is that GPS systems cannot communicate properly with GPS satellites in indoors environments and GPS signals is unable to pass through walls and other indoors obstacles. Recently A-GPS chips can resolve this problem and these chips are able to receive GPS signals in an indoor environment with a reasonable accuracy. The second problem was irregular changes in data received from heart beat sensor. To resolve this problem, this sensor should be isolated from noise and short circuit. As mentioned in online getting started guide of this sensor [18], user can use hot glue to isolate this sensor from noise and short circuit.

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